**PCT** WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/22, 7/30, 7/38

A2

(11) International Publication Number: **WO 98/06226**

(43) International Publication Date: 12 February 1998 (12.02.98)

(21) International Application Number: PCT/SE97/01296

(22) International Filing Date: 18 July 1997 (18.07.97)

(30) Priority Data:
08/692,743 6 August 1996 (06.08.96) US

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventor: LUPIEN, Francis; 4708 Jeanne Mance, Montreal, Quebec H2V 4J4 (CA).

(74) Agents: BANDELIN, Hans et al.; Telefonaktiebolaget LM Ericsson, Patent and Trademark Dept., S-126 25 Stockholm (SE).

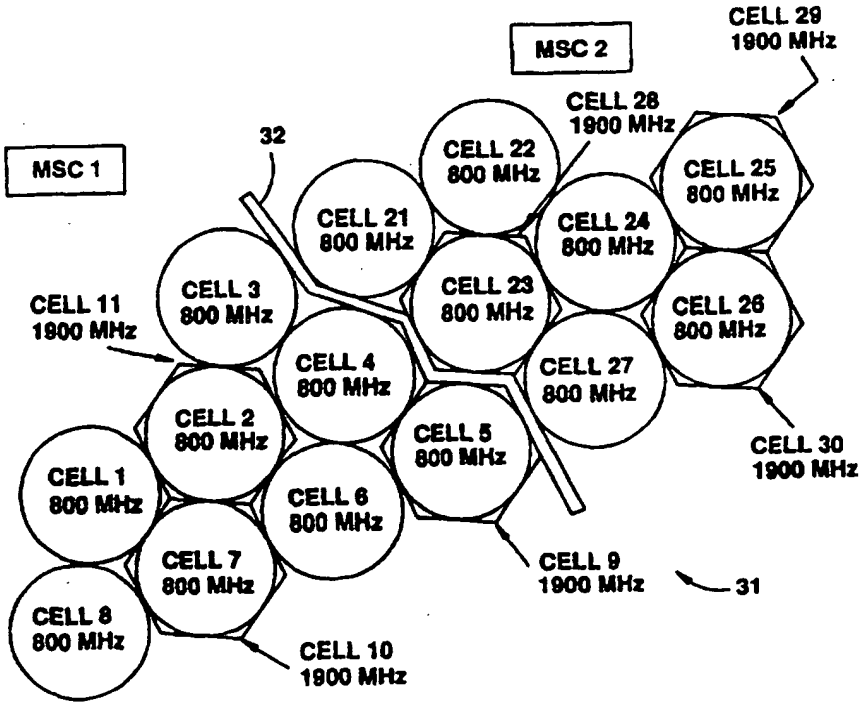
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

**Published**
*Without international search report and to be republished upon receipt of that report.*

(54) Title: CELLULAR TELECOMMUNICATIONS NETWORK HAVING SEAMLESS INTEROPERABILITY BETWEEN EXCHANGES WHILE PROVIDING VOICE, ASYNCHRONOUS DATA AND FACSIMILE SERVICES IN MULTIPLE FREQUENCY HYPERBANDS

(57) Abstract

A system and method of providing seamless interoperability for a mobile station roaming between cellular telecommunication systems (31) operating in multiple hyperbands such as the 1900-MHz PCS hyperband and the 800-MHz cellular telephone hyperband, utilizing United States cellular standards. An enhanced inter-exchange communications protocol based on IS-41 is utilized to communicate information required for seamless interoperability between mobile switching centers (MSCs) (MSC1 and MSC2). The enhanced inter-exchange communications protocol comprises a plurality of signaling messages (41 and 51) and a plurality of modified message parameters (42 and 52) within the signaling messages. The modified message parameters are modified to include information elements (43 and 53) required for seamless interoperability between the multi-hyperband capable exchanges and are added as optional (overriding) parameters to the signaling messages.



# CELLULAR TELECOMMUNICATIONS NETWORK HAVING SEAMLESS INTEROPERABILITY BETWEEN EXCHANGES WHILE PROVIDING VOICE, ASYNCHRONOUS DATA AND FACSIMILE SERVICES IN MULTIPLE FREQUENCY HYPERBANDS

## CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. Patent Application Serial No. 08/543,022, titled "Cellular Telecommunications Network Having Seamless Interoperability Between Exchanges While Supporting Operation in Multiple Frequency Hyperbands," filed October 13, 1995 and hereby incorporated by reference as if quoted in its entirety herein.

## BACKGROUND OF THE INVENTION

### Technical Field of the Invention

This invention relates to cellular telecommunications networks and, more particularly, to a cellular telecommunications network utilizing United States cellular standards and providing seamless interoperability between exchanges operating in both 800-MHz and 1900-Mhz hyperbands.

### Description of Related Art

North American cellular telecommunications networks have traditionally operated in two frequency bands (A and B) in the 800-MHz hyperband. The most recent evolution in cellular telecommunications involves the adoption of six additional frequency bands (A - F) in the 1900-MHz hyperband for use in handling mobile and personal communications. The 1900-MHz hyperband is also known as the Personal Communication Services (PCS) hyperband. Frequency bands within the 800-MHz hyperband and the 1900-MHz hyperband are defined in EIA/TIA Standard IS-136 and the PN3388-1 and PN3388-2 Specifications, which are hereby incorporated by reference herein. Other standards which

both 800 MHz and 1900 MHz. As more frequency hyperbands come into use, roaming mobile stations will roam through an increasingly complex map of available hyperbands.

As a mobile station roams out of the coverage area of a cell, measurements of signal strengths of neighboring cells must be taken to assess whether the mobile station should reselect a particular neighboring cell for service (when in the idle mode) or be handed off to the neighboring cell (when in the busy mode). Existing cellular telecommunications networks, however, are not capable of performing the functions necessary to provide seamless interoperability between cells operating in different hyperbands and in different MSCs.

Telephone calls involving asynchronous data and facsimile (fax) services impose additional requirements on the telecommunication network. In order to establish and maintain a robust connection acceptable for the transmission of data and fax services between exchanges, an enhanced intersystem signaling protocol is required to communicate a set of commands between MSCs. This enhanced intersystem signaling protocol is distinctly different from the protocol necessary for voice transmission, and must provide a terminating MSC with information necessary in call delivery and/or handoff of voice, data or fax calls. In addition, intersystem signaling messages must provide information and verification on whether a particular subscriber has authorization to use the data and fax services.

Although there are no known prior art teachings of a solution to the aforementioned deficiency and shortcoming such as that disclosed herein, a prior art reference exists that discusses subject matter that bears some relation to matters discussed herein. One such prior art reference is U.S. Patent Number 5,446,553 to Grube. This reference is discussed briefly below.

Grube relates to a wireless fax reception method with roaming. Specifically, the patent provides for a

interoperability between the MSCs. The inter-exchange communications protocol comprises a plurality of signaling messages in an industry standard message format and a plurality of modified message parameters within the signaling messages. The modified message parameters are modified to include information elements required for seamless interoperability between the multi-hyperband capable exchanges.

In another aspect, the present invention is a method of providing seamless interoperability for a mobile station roaming between a plurality of multi-hyperband capable exchanges in a cellular telecommunications network. The method comprises the steps of connecting a plurality of multi-hyperband capable mobile switching centers (MSCs) to a plurality of base stations having transmission and reception equipment operating in a plurality of frequency hyperbands, and communicating information between the MSCs with an inter-exchange communications protocol having a plurality of signaling messages comprising a plurality of message parameters. The communicating step further comprises the steps of formatting the plurality of signaling messages in an industry standard message format and modifying the plurality of message parameters to include information elements required for seamless interoperability between the multi-hyperband capable exchanges.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The invention will be better understood and its numerous objects and advantages will become more apparent to those skilled in the art by reference to the following drawing, in conjunction with the accompanying specification, in which:

FIG. 1 is an illustrative drawing of a portion of a cellular telecommunications network suitable for implementation of the present invention;

FIG. 10 is a signaling diagram illustrating one-stage dialing call delivery between a Gateway Mobile Switching Center (G-MSC) and another MSC;

FIG. 11 is a signaling diagram illustrating two-stage dialing call delivery between a G-MSC and another MSC;

FIGS. 12A-12D are signaling diagrams illustrating service activation and de-activation of terminating calls for asynchronous data and G-3 fax services; and

FIG. 13 is a signaling diagram illustrating the changing of a subscriber profile in the MSC/VLR as a result of a successful Remote Feature Control Request (FEATREQ).

**DETAILED DESCRIPTION OF EMBODIMENTS**

The present invention is a system and method of providing seamless interoperability between cellular systems operating in multiple hyperbands. Although the present invention is not limited to specific frequency bands or a fixed number of hyperbands, the exemplary embodiment described herein discloses a cellular telecommunications network utilizing United States cellular standards and providing seamless interoperability between exchanges operating channels in both the 800-MHz cellular telephone hyperband and the 1900-MHz PCS hyperband.

FIG. 1 is an illustrative drawing of a portion of a cellular telecommunications network 31 suitable for implementation of the present invention. A dark boundary line 32 divides the network into one exchange controlled by MSC 1 and another exchange controlled by MSC 2. Although not shown for simplicity, MSC 1 and MSC 2 are connected by microwave links, fiber optics, cables, or otherwise to base stations in each of the cells in their respective service areas. Cells operating in the 800-MHz hyperband only are illustrated as circles. Cells operating in the 1900-MHz PCS hyperband are illustrated as hexagons. Dual-hyperband capable cells, and areas of

extensions replace existing IS-41 message parameters and provide for multi-exchange, multi-hyperband seamless interoperability through "Enhanced IS-41" signaling. Some required functions may be implemented utilizing standard IS-41 signaling. Other functions may be implemented utilizing Enhanced IS-41 signaling.

The functionality required for seamless interoperability between multi-hyperband exchanges may be implemented in other ways in alternative embodiments. For example, existing information elements within message parameters may be modified and extended to include the additional data required for coordination of both 800-MHz and 1900-MHz systems. However, this method is cumbersome and "messy" due to length restrictions on certain information elements, the fixed format of information elements within parameters, and fixed formats of the parameters themselves. All the messages in IS-41 are octet formatted, therefore, this method requires that another 8-bit information element be tagged onto the back of a message parameter with the additional information needed. Some information elements would need to be reformatted to comply with new definitions, formats, or to accept new values. The total information element may not be contiguous, and the solution is complicated and confusing. By way of example, the existing Digital Channel Data (DCD) and Call Mode (CM) parameters have fixed lengths which limit the number of information elements they contain. The format and range of values of some of those information elements are also restricted. Therefore, these factors make it difficult to accommodate the new additional information required for the simultaneous support of 800-MHz and 1900-MHz systems. Consequently, when utilizing this method, an additional 8-bit information element must be tagged onto the message parameter in order to provide the additional channel number (CHNO) information required in the DCD message parameter.

the Location function and the Presence Verification function, is better suited to handle the call. Handoffs can also be conducted within the same cell to another channel or to and from an overlaid cell such as between a 800-MHz cell and an overlaid 1900-MHz cell.

Seamless interoperability for mobile stations roaming between cells in a multi-hyperband capable MSC requires that each mobile station have complete neighbor cell information, and that each base station have the capability to perform the Location and Presence Verification functions for each hyperband utilized in the base station and its neighbor cells. For mobile stations in the busy (on-call) operating mode, there are two alternative methods of performing the Location function and identifying when a handoff should be initiated. One method utilizes mobile assisted handoff (MAHO), and the mobile station performs the Location function. When a mobile station begins operating on a digital traffic channel, the mobile station measures the quality of the radio link connection by measuring the bit error rate and the received signal strength on its assigned channel. The mobile station also measures the signal quality of channels in neighboring cells indicated in a measurement order from the base station. The channels included in the measurement order are reference frequencies of neighboring cells. In accordance with the teachings of the present invention, mobile stations that are dual-hyperband capable receive a neighbor list that includes neighbor cells and outer cells operating at both 800 MHz and 1900 MHz. Mobile stations that operate only in the 800-MHz cellular telephone hyperband receive a neighbor list that includes only neighbor cells and outer cells operating at 800-MHz. The base station receives channel quality messages from its neighboring cells and compares the channels with each other. The base station considers received signal strength and propagation path loss (transmitted power level minus received signal strength). Parameters in the

is made in the candidate handoff cell utilizing its location and verification device, and if the signal strength exceeds a predetermined threshold, the handoff is initiated. When operating on an analog voice channel, signal strength is measured on the voice channel for the serving channel Supervisory Audio Tone (SAT). The verification information is reported to the MSC.

Presence verification may be performed with or without the use of MAHO to perform the Location function. Presence Verification measurements are made by the location and verification devices in the base station of the candidate handoff cell. There may be a separate location and verification device for each hyperband, or a single location and verification device having a signal strength receiver capable of measuring signal strengths in multiple hyperbands. If a multi-hyperband capable mobile station is operating in a 800-MHz cell, the present invention determines whether it is better to operate in another 800-MHz cell or in a cell in any other measured hyperband.

FIGS. 2A-2C are high level block diagrams of alternative embodiments of a location and verification device 35 which performs cyclical location measurements as well as the verification signal strength measurement on demand. Referring first to FIG. 2A, it is shown that each location and verification device comprises a control unit (CU) 101, a signal strength receiver (SSR) 102, a receiver (RX) 103, and a verification device (VER) 104. The location and verification device 35 utilizes the SSR 102 and RX 103 to perform cyclical sampling measurements of radio signals received from mobile stations operating on voice channel frequencies allocated to neighboring cells. The results of the sampling measurements are updated in the CU 101 as a mean value (also considering previous measurements) after each sampling cycle. This mean value is provided to neighboring cells upon request in order to ascertain whether the cell operating the

MSC. Handoffs may also be performed across exchange boundaries between a cell in one MSC and an outer cell in another MSC. In addition to performing the Location, Presence Verification, and Handoff functions in multiple hyperbands, cellular networks supporting multi-hyperband, inter-exchange handoffs for mobile stations must exchange outer cell information and hyperband information between the MSCs involved. The standard protocol for inter-exchange signaling is IS-41. When an inter-exchange handoff is performed between single hyperband MSCs, known IS-41 messages are utilized to carry required information between the exchanges for handoff of the call. These messages may include a handoff measurement request (HandMeasReq) message, a facilities directive (FacDir) message, a Handoff Back (HandBack) message, and a handoff-to-third (HandThird) message.

The handoff measurement request message is utilized to request locating measurements for outer cells in the classical location method, in order to assess the best candidate outer cell for handoff. The same message is also utilized to request Presence Verification information in neighbor outer cells, in order to verify the presence of the mobile station in those cells and assess the best candidate outer cell. If the serving MSC determines that the handoff is to be made to an outer cell in a neighboring MSC, then a voice channel is requested.

When multiple hyperbands are in use in the MSCs involved in a handoff, new message parameters are required at handoff to select a hyperband based on the requested call mode, the mobile station frequency hyperband capability, signal quality with neighbor outer cells, and hyperband capability of neighbor outer cell base stations, and to select radio equipment operating in the selected hyperband. The new message parameters are described below.

FIG. 3 is an illustrative drawing of a signaling message constructed in accordance with the standard IS-41

added as message suffixes. The optional HDCD message parameter 55 replaces the existing DCD message parameter 52 and includes a 24-bit Hyperband Channel Number (HCHNO) information element 56. The HCHNO information element 56 may further comprise a 16-bit CHNO information element 57 and an 8-bit Hyperband (HYBA) information element 58 capable of accommodating the new additional information required for the simultaneous support of multi-hyperband systems.

Information Elements

Table 1 illustrates the applicable information elements that are utilized in the enhanced IS-41 signaling messages to implement full seamless interoperability between multi-hyperband exchanges providing voice, data, and fax services utilizing United States cellular standards. Each of these information elements is discussed in the following paragraphs.

| | INFORMATION ELEMENTS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MESSAGES | TSR | DMAC | DVCC | CHNO | HYBA | BW | VM | SC | TDC | PV | VCC | ISLP |
| RegNot RR | | | | | | X | | X | | | X | |
| QualDir INV | | | | | | X | | X | | | X | |
| QualReq RR | | | | | | X | | X | | | X | |
| LocReq INV | | | | | | | | X | | | | |
| LocReq RR | | | | | | | | X | | | | |
| Route Req INV | | | | | | | | X | | | | |
| Route Req RR | | | | | | | | X | | | | |
| FacDir INV | Y | Z | Z | Z | X | X | X | X | X | X | | X |
| HandBack INV | Y | Z | Z | Z | X | X | X | X | X | X | | |
| HandThird INV | Y | Z | Z | Z | X | X | X | X | X | X | | |
| FacDir RR | Y | Z | Z | Z | X | | | | | | | X |
| HandBack RR | Y | Z | Z | Z | X | | | | | | | |
| HandThird RR | Y | Z | Z | Z | X | | | | | | | |
| HandMeasReq INV | Y | Z | Z | Z | X | X | X | X | | | | |
| InterSys Page INV | | | | | | | | X | X | X | | |

Key: - X: New information element
- Y: Existing information element that requires extensions
- Z: Existing information (not requiring extension)

Table 1: Information Elements in Enhanced IS-41 Messages

frequency hyperbands are identified. It should be understood, however, that the present invention may support inter-exchange handoffs between MSCs operating in a greater number of frequency hyperbands. In order to ensure multi-hyperband support, the HYBA parameter is of variable length, with values $hyba_1 \ldots hyba_n$.

| Hyperband |
|---|
| 800 MHz |
| 1900 MHz |
| • • • |

Table 2: Hyperband (HYBA)

Bandwidth (BW)

The Bandwidth (BW) information element is supported in the MSC and identifies the digital traffic channel bandwidth requirements for the requested call as shown in Table 3. The BW information element is transferred during an inter-exchange handoff and is included in inter-exchange handoff related messages to identify variable call rates (half rate, full rate, etc.).

| Bandwidth |
|---|
| Half Rate Digital Traffic Channel Only |
| Full Rate Digital Traffic Channel Only |
| Half or Full Rate DTC - Full Rate Preferred |
| Half or Full Rate DTC - Half Rate Preferred |
| Double Full Rate DTC Only |
| Triple Full Rate DTC Only |

Table 3: Bandwidth (BW)

| Service Code |
| --- |
| Analog Speech Only |
| Digital Speech Only |
| Analog or Digital - Analog Preferred |
| Analog or Digital - Digital Preferred |
| Async Data |
| G3 Fax |
| • • • |

Table 5: Service Code (SC)

Terminal Band Capability (TBC)

The Terminal Band Capability (TBC) information element is supported in the MSC and indicates the frequency bands supported by the mobile station as shown in Table 6. The TBC information element is transferred during an inter-exchange handoff in order to distinguish the bands supported by the mobile station/terminal due to channel limitations of the terminal. In order to ensure multi-hyperband support, additional hyperbands and bands may be added as desired. Note here that the terminal's band capabilities are determined and dictated by the terminal itself.

Voice Coder Capability

The Voice Coder Capability (VCC) information element is supported in the home location register (HLR) and in combined visitor location registers/mobile switching centers (VLR/MSC) and specifies which voice coder the subscriber is capable of supporting as shown in Table 8. This information either allows the subscriber to obtain service or restricts the subscriber from obtaining service dependent on the supported voice coder level. Additional voice coders may be added to the information element as desired. The VCC is included as part of the subscriber profile.

| Voice Coder Capability |
|---|
| No Voice Coders Supported |
| VSELP Voice Coder Supported |
| SOC/BMSC Specific Signaling |
| High Quality Voice Coder Supported |
| • • • |

Table 8: Voice Coder Capability (VCC)

Intersystem Link Protocol

The Intersystem Link Protocol (ISLP) information element is supported in the MSC/VLR and specifies the protocol to be used on inter-MSC trunks during intersystem handoff of a data call as shown in Table 9 below. The protocol types are defined in IS-41.

Time Divided Multiple Access (TDMA) systems utilize IS-136 and provide a related family of standardized digital services. IS-130 is the protocol used to convey data stream information (asynchronous, synchronous, etc.) over the air interface. However, IS-130 does not convey coded voice over the digital traffic channel (DTC). The Radio Link Protocol defined by IS-130, specifies how the

The HDCD parameter is used to indicate the TSR, the DMAC, the DVCC, the CHNO, and the HYBA of a digital channel.

Hyperband Call Mode (HCM)

A new optional parameter termed the "Hyperband Call Mode" (HCM) includes the following information elements:

- Preferred Bandwidth (BW);
- Voice Mode (VM); and
- Service Code (SC).

The HCM parameter is utilized to indicate the preferred BW, VM, and SC modes of the current hyperband call.

Terminal Characteristics (TCH)

A new optional parameter termed the "Terminal Characteristics" (TCH) includes at least the following information elements:

- Terminal Band Capability (TBC); and
- Protocol Version (PV).

The TCH parameter is used to indicate the TBC and the supported PV of the mobile station (terminal) (i.e. the frequency bands and protocol version supported by the terminal). It may also include information elements indicative of other terminal characteristics such as analog voice channel, asynchronous data and fax service support.

Subscriber Characteristics (SCH)

A new optional parameter termed the "Subscriber Characteristics" (SCH) includes at least the following information elements:

- Bandwidth (BW);
- Voice Coder Capability (VCC); and
- Service Code (SC).

The features supported by the subscription will be included in the SCH parameter. This is also referred to

ENHANCED IS-41 MESSAGES

The key transactions/messages defined by the present invention are listed in Table 1. The messages support either call delivery or inter-hyperband/inter-exchange handoffs, as indicated. In particular, these messages support handoffs between two hyperbands (i.e., from 800 MHz to 1900 MHz and vice versa), and between cells in two exchanges both operating at 1900 MHz. The messages include:

Registration Notification Return Result (RegNot RR)

This message is modified in order to support call delivery. If the subscriber is allowed to roam, the HLR will include the VCC, SC and BW information elements in the Subscriber Characteristics (SCH) parameter as part of the subscriber profile in the RegNot RR message sent towards the V-MSC. The use of the RegNot RR message and SCH parameter is illustrated in FIG. 8.

Qualification Directive Invoke (QualDir INV)

This message is modified in order to support call delivery. At any change in a roaming subscriber's profile, the HLR forwards to the V-MSC, a QualDir INV message including the VCC, SC and BW information elements as part of the Subscriber Characteristics (SCH) parameter. The use of the QualDir INV message and SCH parameter is illustrated in FIG. 8.

Qualification Request Return Result (QualReq RR)

This message is also modified in order to support call delivery. If the V-MSC determines that a roaming subscriber needs to be validated in order to be provided service, the HLR sends to the V-MSC a QualReq RR message including the VCC, SC and BW information elements as part of the Subscriber Characteristics (SCH) parameter. The use of the QualReq RR message and SCH parameter is illustrated in FIG. 8.

Facilities Directive Invoke (FacDir INV)

This message is modified to support the inter-hyperband/inter-exchange handoff process including voice, asynchronous data and G3 fax services. During the inter-hyperband/inter-exchange handoff process, the serving MSC (anchor MSC) indicates to the target MSC via a Facilities Directive Invoke message, information that includes the frequency bands supported by the mobile station, the current serving hyperband of the mobile station, and the protocol to be used on inter-MSC trunks during intersystem handoff of circuit switched data calls. This information is conveyed by including in the FacDir INV message the HDCD, HCM, TCH and Inter-MSC Circuit Info message parameters.

Handoff Back Invoke (HandBack INV)

This message is modified to support the inter-hyperband/inter-exchange handoff process including voice, asynchronous data, and G3 fax services. If the serving MSC decides to handoff the mobile station back to the previously-serving MSC (i.e., anchor exchange), the serving MSC sends to the target MSC (i.e., anchor exchange) a Handoff Back Invoke message with information on the current serving hyperband of the mobile station. This information is conveyed by including the HDCD, HCM, and TCH message parameters in the HandBack INV message.

Handoff to Third Invoke (HandThird INV)

This message is modified to support the inter-hyperband/inter-exchange handoff process including voice, asynchronous data, and G3 fax services. If the serving MSC (non-anchor) decides to make a handoff of the mobile station to a new third target exchange (not the anchor exchange), the serving MSC sends a Handoff to Third Invoke message toward the anchor MSC to perform path minimization with information on the current serving hyperband of the mobile station. This information is conveyed by including

serving exchange indicating the new voice channel. This information is conveyed by including the HDCD message parameter in the HandThird RR message.

Handoff Measurement Request Invoke (HandMeasReq INV)

This message is modified to support the inter-hyperband/inter-exchange handoff process. The serving MSC sends a Handoff Measurement Request Invoke message to the cooperating exchange initiating location measurements in the cooperating MSC. The HandMeasReq INV message contains the serving hyperband of the mobile station. This information is conveyed by including the HDCD and the HCM message parameters in the HandMeasReq INV message. Private information allowing inter-exchange mobile station presence verification is also included in the HandMeasReq INV message.

A number of additional parameters are added to the HandMeasReq INV message as well as the Handoff Measurement Request Return Result (HandMeasReq RR) message in order to support the Presence Verification function as shown in Table 10 below.

terminal information regarding asynchronous data and fax service support in the terminal. The use of the InterSys Page INV message is illustrated in FIG. 9.

FIG. 5 is a signaling diagram illustrating the flow of messages during handoff of a mobile station from an anchor MSC 61 to a target MSC 62 in the preferred embodiment of the cellular telecommunications network of the present invention. The process begins when the anchor MSC 61 sends a Handoff Measurement Request Invoke message 63 to the target MSC 62. The Handoff Measurement Request Invoke message may include the HDCD and the HCM message parameters. The target MSC 62 then returns a Handoff Measurement Request Return Result message 64 to the anchor MSC 61. The anchor MSC then sends a Facilities Directive Invoke message 65 to the target MSC and may include the HDCD, HCM, TCH and Inter-MSC Circuit Info message parameters. The target MSC returns a Facilities Directive Return Result message 66 and may include the HDCD and Inter-MSC Circuit Info message parameters. The target MSC 62 then sends a Mobile on Channel Invoke message 67 to the anchor MSC 61 when the handoff is complete.

FIG. 6 is a signaling diagram illustrating the flow of messages between an anchor MSC 71, a serving MSC 72, and a target MSC 73 during handoff-to-third with path minimization of a mobile station from the serving MSC 72 to the target MSC 73 in the preferred embodiment of the cellular telecommunications network of the present invention. The handoff-to-third process begins when the serving MSC sends a Handoff Measurement Request Invoke message 74 to the target MSC and may include the HDCD and the HCM message parameters. The target MSC 73 returns a Handoff Measurement Request Return Result message 75 to the serving MSC. The serving MSC 72 then sends a Handoff to Third Invoke message 76 to the anchor MSC 71 and may include the HDCD, HCM, and TCH message parameters. The anchor MSC 71 then sends a Facilities Directive Invoke message 77 to the target MSC 73 and may include the HDCD,

MSC 131 to the HLR 132 when a roaming subscriber attempts to register in the V-MSC. If the subscriber is allowed to roam, the HLR includes the Subscriber Characteristics (SCH) parameter as part of the subscriber profile in a Registration Notification Return Result (RegNot RR) message 134 sent towards the V-MSC.

FIG. 8 next illustrates a Qualification Request Invoke (QualReq INV) message 135 that is sent from the V-MSC 131 to the HLR 132 if the V-MSC requires validation of a roaming subscriber in order to provide service. The HLR then sends to the V-MSC a Qualification Request Return Result (QualReq RR) message 136 including the Subscriber Characteristics (SCH) parameter.

FIG. 8 next illustrates a Qualification Directive Invoke (QualDir INV) message 137 that is sent from the HLR 132 to the V-MSC 131 at any change in a roaming subscriber's profile. The QualDir INV message includes the Subscriber Characteristics (SCH) parameter. The V-MSC 131 then returns a Qualification Directive Return Result (QualDir RR) message 138 to the HLR 132.

FIG. 9 is a signaling diagram illustrating intersystem page messages between a candidate visited MSC 141 and a border MSC 142 in the preferred embodiment of the present invention. When a subscriber has "roamed away" from a serving visited exchange, a page attempt is made by the system to reach the subscriber in a border exchange. Consequently, during the paging process, the current V-MSC performing intersystem paging (candidate V-MSC), sends to the border exchange, an Intersystem Page Invoke (InterSys Page INV) message 143 including information on the supported bands and hyperbands of the mobile station and the type of service provided (voice, asynchronous data, and G3 fax). This information is conveyed by including the TCH and Service Info message parameters (including the SC information element) in the InterSys Page INV message. The border MSC 142 then returns an Intersystem Page Return Result (InterSys Page

of accepting the call. Therefore, the MSC/VLR 153 returns a RN and the accepted service code (SC) in the Route Request Return Result 156 message. When the RN is received by the G-MSC 151, the call is routed at 158 to the MSC/VLR 153. Additionally, the MSC/VLR 153 handles the routed call and provides the requested service.

FIG. 11 is a signaling diagram illustrating two-stage dialing call delivery between a G-MSC and another MSC. A calling PSTN subscriber places a data or fax call through a modem to a called cellular subscriber. The dialed number corresponds to the cellular carrier's asynchronous data or G3 fax service number, which is recognized by the PSTN. The PSTN subscriber's modem receives a second dial tone. Upon receiving this dial tone, the PSTN subscriber's modem dials the called cellular subscriber's DN.

When the cellular carrier's asynchronous data or G3 fax service number is dialed, the PSTN routes the call to the corresponding G-MSC 160. Upon recognizing an incoming call from the PSTN as the asynchronous data or G3 fax service number, the G-MSC 160 sends a second dial tone toward the calling PSTN's modem to request the called cellular subscriber's DN. Upon receiving this DN, the G-MSC 160 queries the HLR 161 for the called subscriber's RN (e.g., Temporary Location Directory Number (TLDN)), and indicates the requested service call information (asynchronous data or G3 fax) in the Location Request Invoke message 163. Upon reception of a LocReq INV message, the HLR 161 interrogates the appropriate MSC/VLR 162 for the RN of the cellular subscriber in a Routing Request Invoke message 164 if the service is subscribed to and is found to be activated. The Routing Request Invoke message 164 contains an indication of the requested service. When the MSC/VLR 162 receives the RN interrogation for a visiting subscriber, it verifies the indication of the requested service in the message. This information is used to set up the call to the visiting

HLR 182 updates the status accordingly. The HLR 182 sends a Remote Feature Control request result message 183 to MSC 180.

FIG. 12C illustrates the messages involved in the activation of a terminating call for G3 fax services. Upon the reception of a feature code call in the V-MSC 190 from the subscriber, the V-MSC 190 sends a Remote Feature Control Request Invoke message 191 to HLR 192 with the appropriate information (MIN, Service Code, Activation Status) to update the subscriber's status. The HLR 192 updates the status accordingly. The HLR 192 sends a Remote Feature Control request result message 193 to MSC 190.

FIG. 12D illustrates the messages involved in the de-activation of a terminating call for G3 fax services. Upon the reception of a feature code call in the V-MSC 200 from the subscriber, the V-MSC 200 sends a Remote Feature Control Request Invoke message 201 to HLR 202 with the appropriate information (MIN, Service Code, Activation Status) to update the subscriber's status. The HLR 202 updates the status accordingly. The HLR 202 sends a Remote Feature Control request result message 203 to MSC 200.

FIG. 13 is a signaling diagram illustrating the updating of a subscriber's profile to an MSC/VLR with a Qualification Directive (QUALDIR). When a Remote Feature Control Request message (See FIGS. 12A-12D) results in a change of a subscriber profile, the HLR 212 reports the change of profile to V-MSC 210 (where the subscriber is registered) through a Qualification Directive Invoke message 211. The FEATREQ message alters the profile by modifying the activation field associated with the authorized services. The V-MSC 210 then sends a QUALDIR Return Result message 213 to HLR 212.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description. While the method,

**WHAT IS CLAIMED IS:**

1. A cellular telecommunications network providing seamless interoperability for voice calls, asynchronous data calls and facsimile calls for a mobile station roaming between multi-hyperband capable exchanges, said cellular telecommunications network comprising:

a plurality of multi-hyperband capable mobile switching centers (MSCs);

a plurality of base stations connected to each of said plurality of MSCs, said base stations having transmission and reception equipment operating in a plurality of frequency hyperbands;

an inter-exchange communications protocol for communicating information required for seamless interoperability between said plurality of MSCs, said inter-exchange communications protocol comprising:

a plurality of signaling messages in an industry standard message format; and

a plurality of modified message parameters within said signaling messages, said modified message parameters being modified to include information elements required for seamless interoperability between said multi-hyperband capable exchanges.

2. The cellular telecommunications network of claim 1 wherein said industry standard message format is the IS-41 message format.

3. The cellular telecommunications network of claim 2 wherein said transmission and reception equipment operates in an 800-MHz cellular telephone hyperband and a 1900-MHz personal communication system (PCS) hyperband.

4. The cellular telecommunications network of claim 2 wherein said modified message parameters include new

an information element that provides frequency band information for specifying a hyperband for a channel;

an information element that identifies digital traffic channel bandwidth requirements;

an information element that identifies a voice mode for requested voice calls;

an information element that identifies requested services;

an information element that indicates which frequency bands and hyperbands are supported by a mobile station;

an information element that indicates a mobile station's protocol version;

an information element that indicates which voice coders are supported by a mobile subscriber; and

an information element that indicates an intersystem link protocol for asynchronous data calls and facsimile calls between exchanges.

10. The cellular telecommunications network of claim 9 wherein said optional parameters include Hyperband Digital Channel Data (HDCD), Hyperband Call Mode (HCM), Terminal Characteristics (TCH), and Subscriber Characteristics (SCH).

11. The cellular telecommunications network of claim 10 wherein a first subset of said plurality of signaling messages supports call delivery for voice, asynchronous data, and facsimile services to said mobile station.

12. The cellular telecommunications network of claim 11 wherein said first subset of said plurality of signaling messages includes a Registration Notification Return Result message, a Qualification Directive Invoke message, a Qualification Request Return Result message, a Location Request Invoke message, a Location Request Return Result message, a Routing Request Invoke message,

seamless interoperability between said multi-hyperband capable exchanges.

16. The method of claim 15 wherein said step of formatting said plurality of signaling messages in an industry standard message format includes formatting said messages in the IS-41 message format.

17. The method of claim 16 wherein said step of connecting to each MSC, a plurality of base stations includes connecting base stations having transmission and reception equipment that operates in an 800-MHz cellular telephone hyperband and a 1900-MHz personal communication system (PCS) hyperband.

18. The method of claim 16 wherein said step of modifying said plurality of signaling messages and said plurality of message parameters includes adding new optional parameters that override mandatory parameters in said signaling messages, said optional parameters including said information elements required for seamless interoperability between said multi-hyperband capable exchanges.

19. The method of claim 18 wherein said step of adding new optional parameters that override mandatory parameters in said signaling messages includes adding optional parameters with unmodified IS-41 information elements, modified IS-41 information elements, and new information elements.

20. The method of claim 19 wherein said step of modifying said plurality of signaling messages and said plurality of message parameters includes adding new optional parameters that replace existing optional parameters in said signaling messages, said new optional parameters including said information elements required

FIG.1

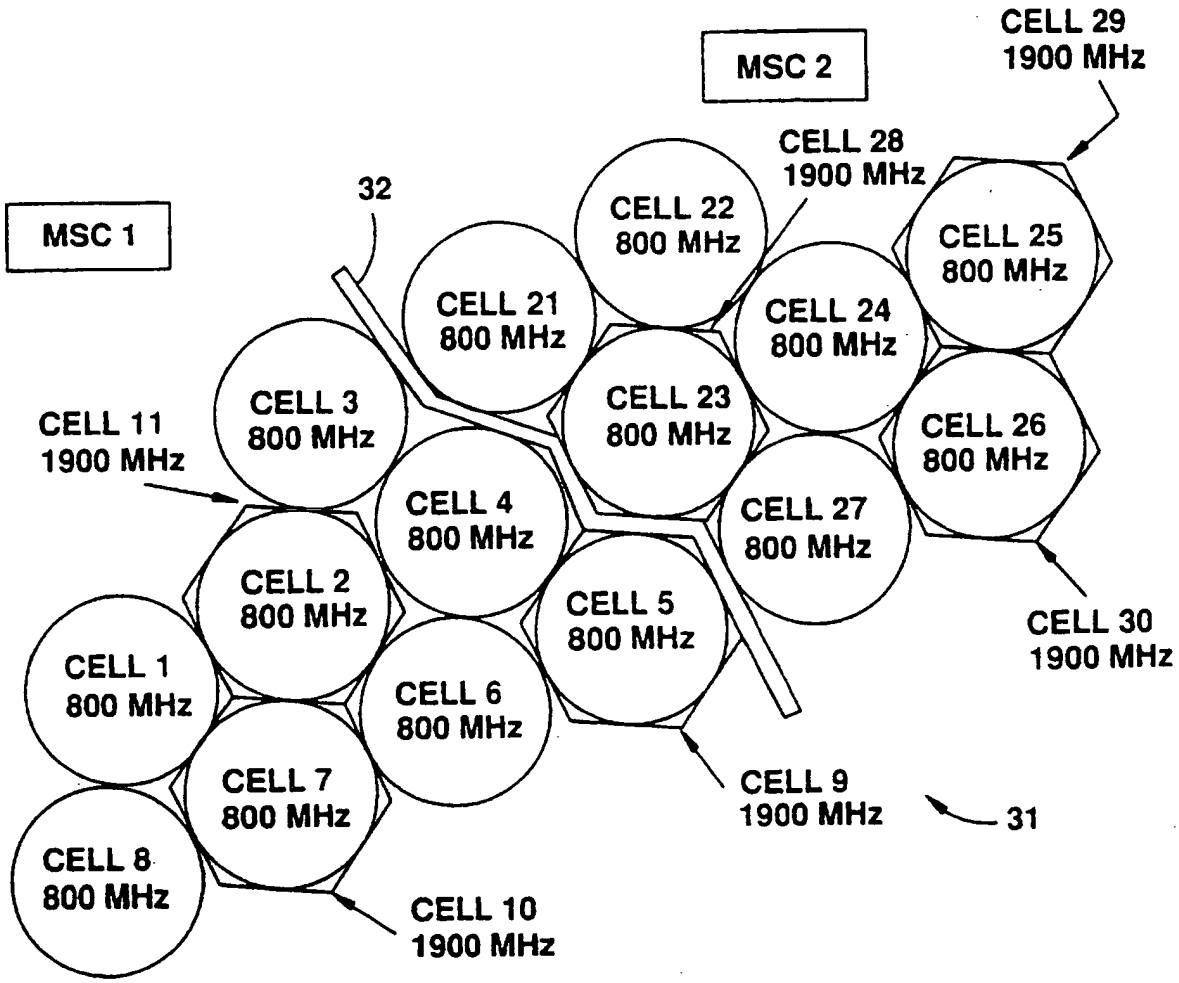


FIG.3

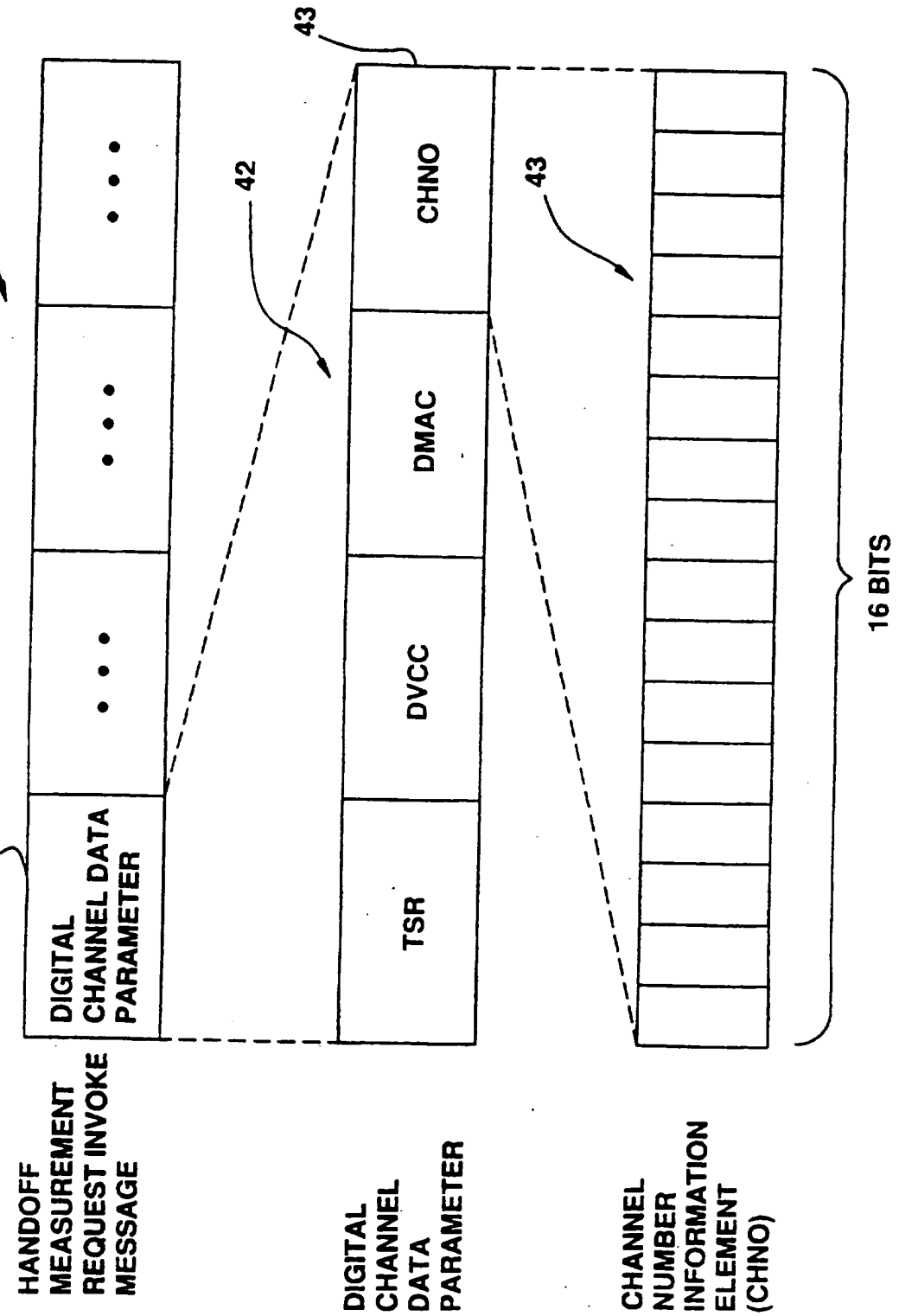


FIG.5

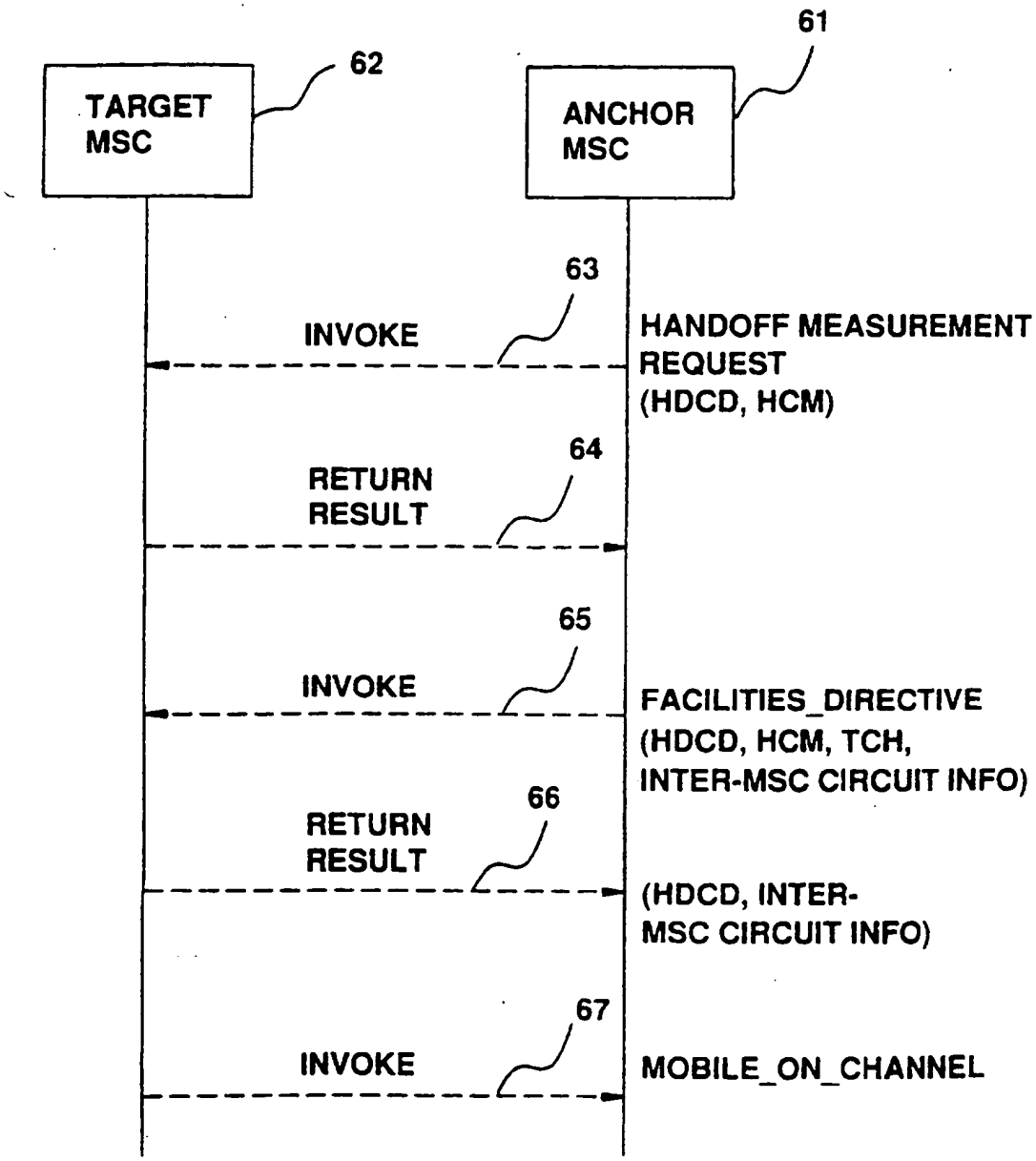


FIG.7

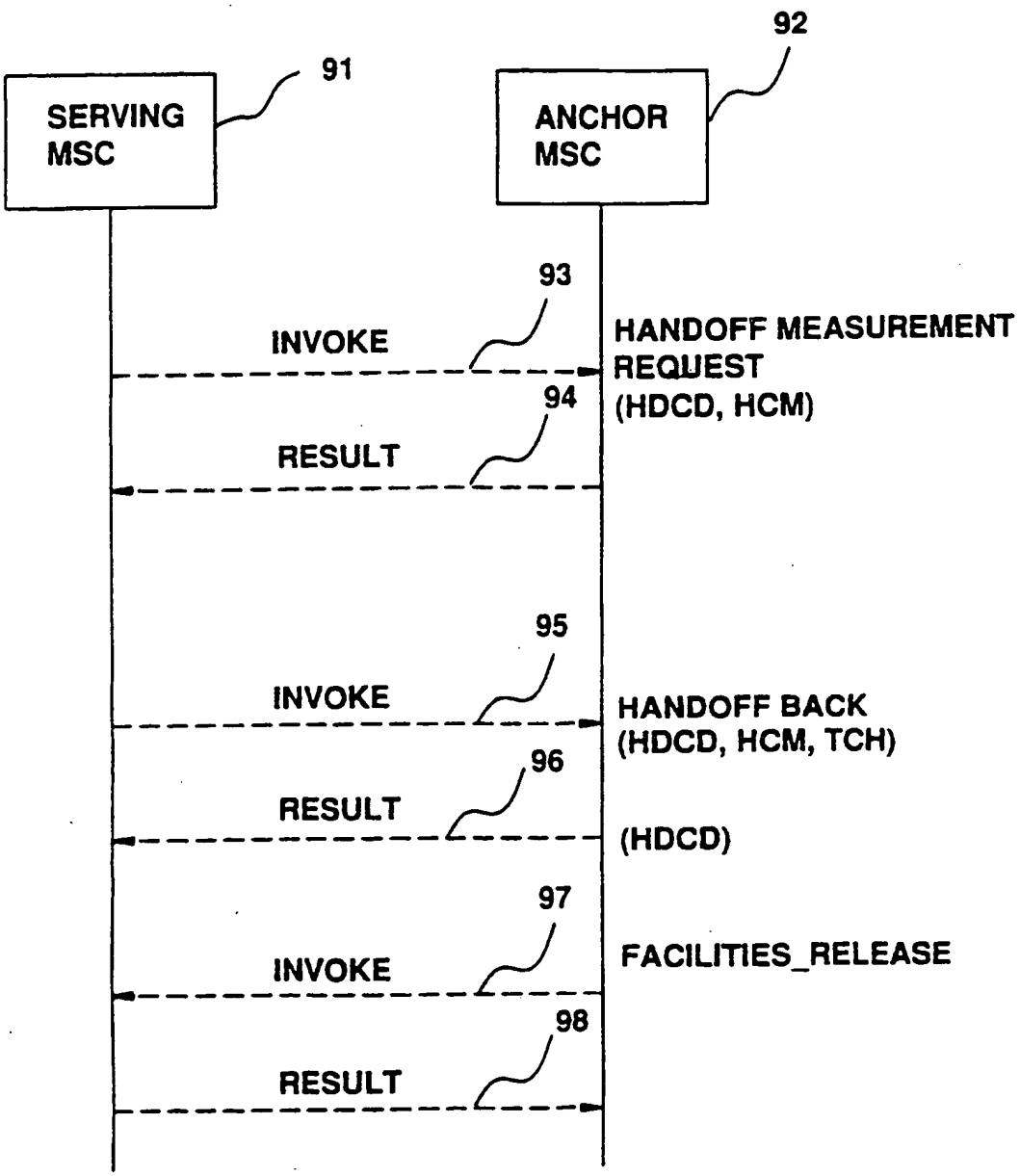


FIG.9

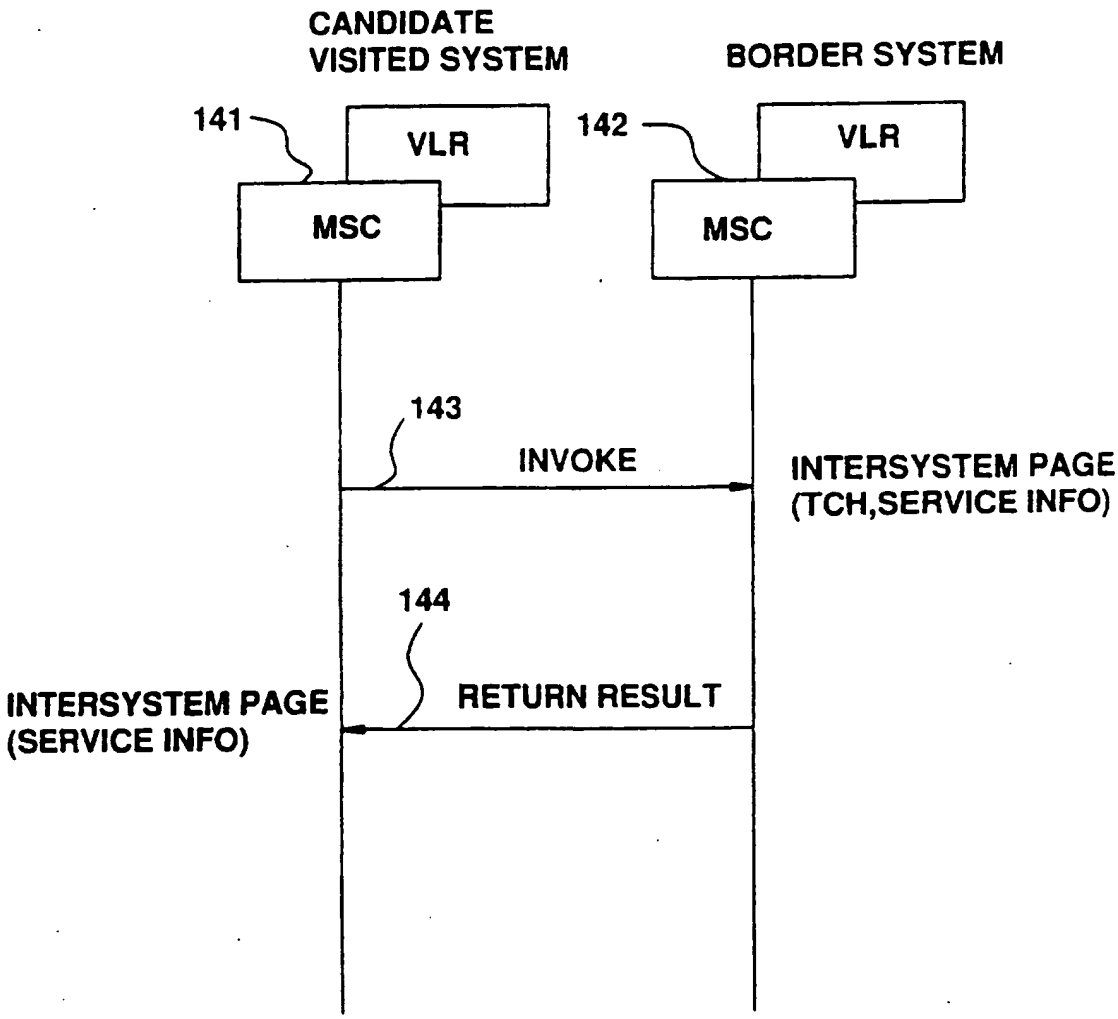


FIG.11

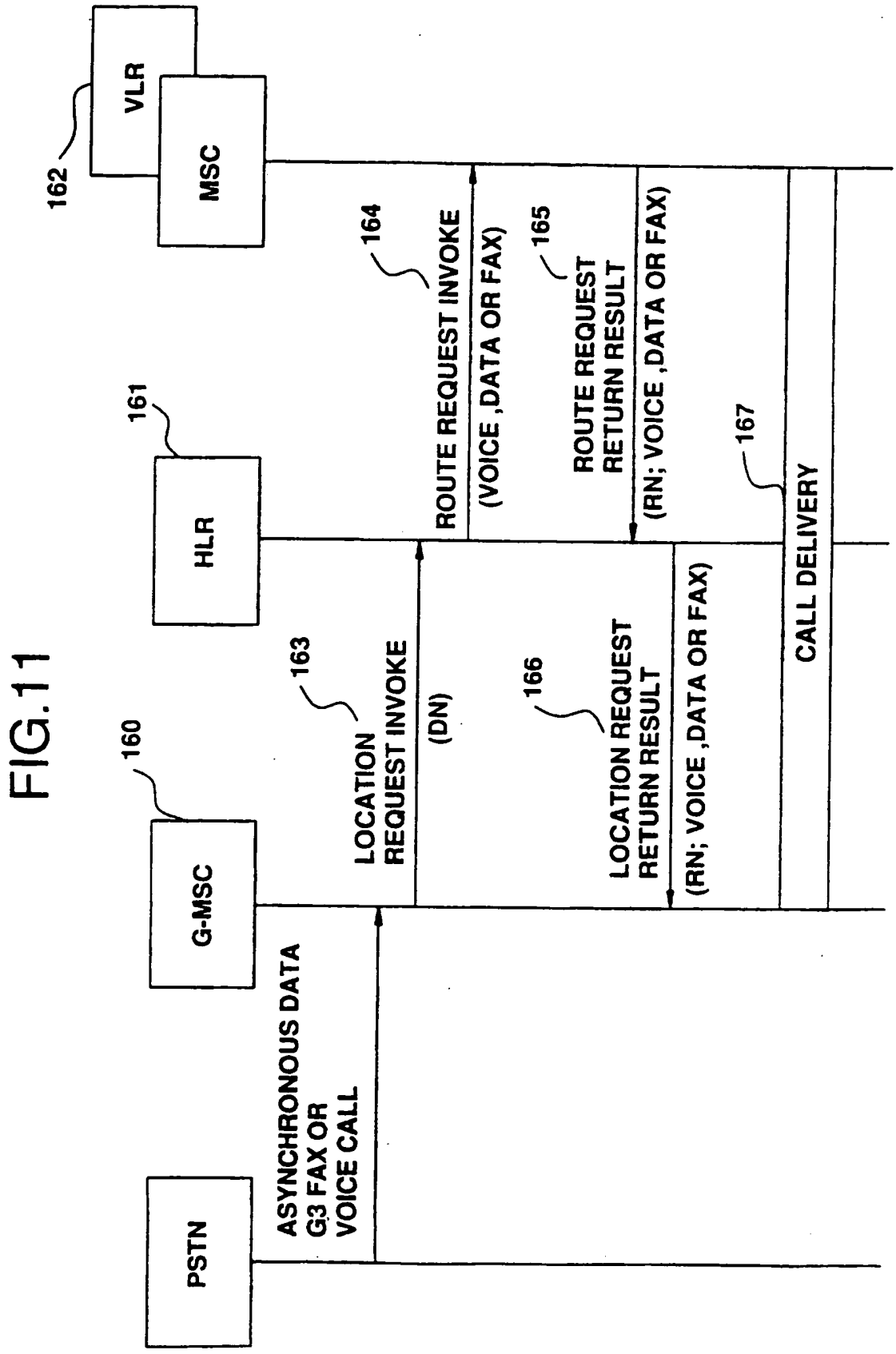

PSTN
G-MSC
160
HLR
161
VLR
MSC
162
ASYNCHRONOUS DATA
G3 FAX OR
VOICE CALL
LOCATION
REQUEST INVOKE
(DN)
163
LOCATION REQUEST
RETURN RESULT
(RN; VOICE ,DATA OR FAX)
166
CALL DELIVERY
167
ROUTE REQUEST INVOKE
(VOICE ,DATA OR FAX)
164
ROUTE REQUEST
RETURN RESULT
(RN; VOICE ,DATA OR FAX)
165

FIG.12C

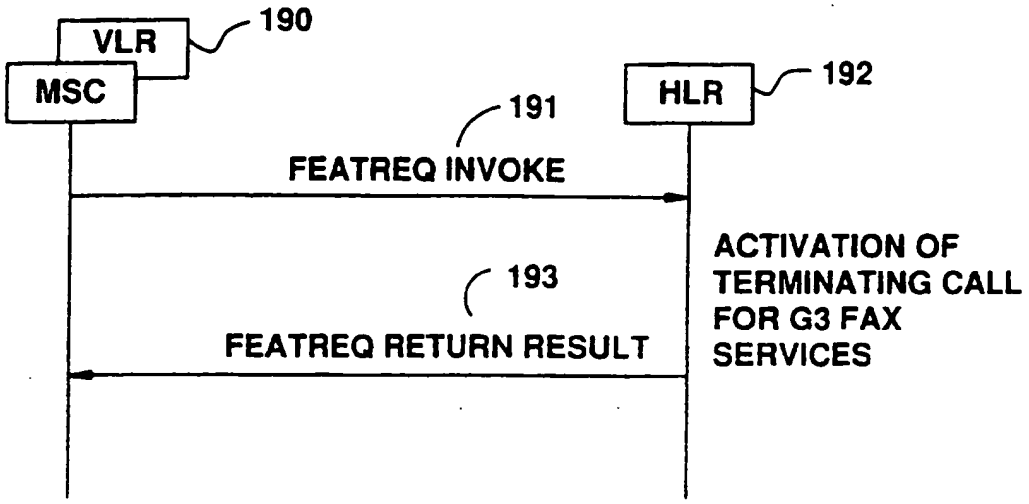



FIG.12D

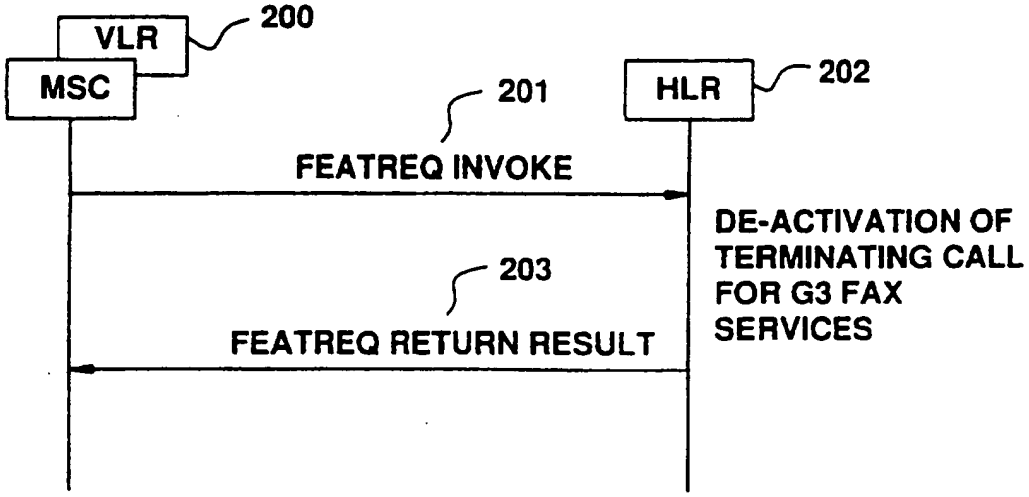
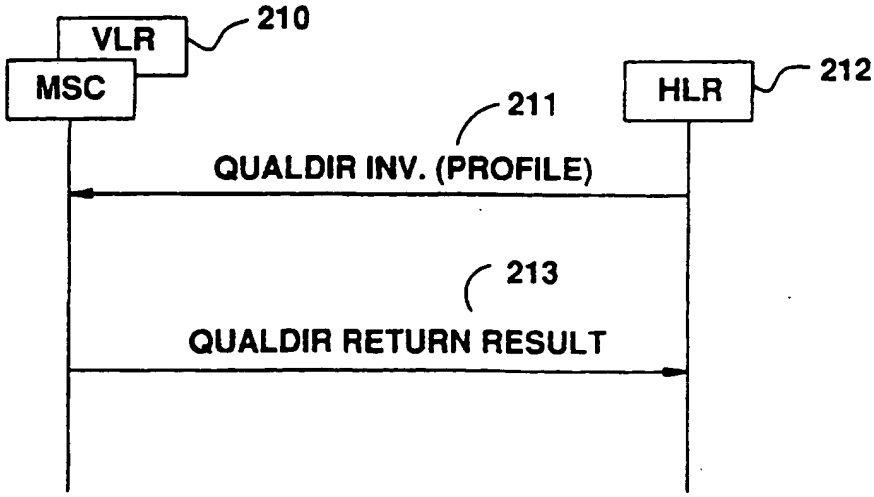



FIG.13



PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/22, 7/30, 7/38 — A3

(11) International Publication Number: WO 98/06226

(43) International Publication Date: 12 February 1998 (12.02.98)

(21) International Application Number: PCT/SE97/01296

(22) International Filing Date: 18 July 1997 (18.07.97)

(30) Priority Data:
08/692,743 6 August 1996 (06.08.96) US

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventor: LUPIEN, Francis; 4708 Jeanne Mance, Montreal, Quebec H2V 4J4 (CA).

(74) Agents: BANDELIN, Hans et al.; Telefonaktiebolaget LM Ericsson, Patent and Trademark Dept., S-126 25 Stockholm (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

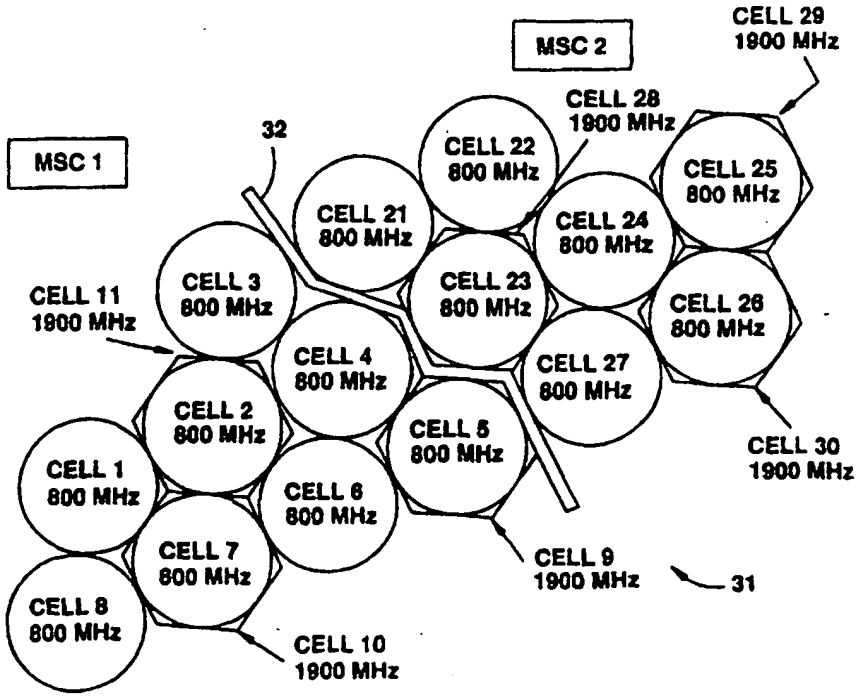
**Published**
*With international search report.*
*Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(88) Date of publication of the international search report:
19 March 1998 (19.03.98)

(54) Title: CELLULAR TELECOMMUNICATIONS NETWORK HAVING SEAMLESS INTEROPERABILITY BETWEEN EXCHANGES WHILE PROVIDING VOICE, ASYNCHRONOUS DATA AND FACSIMILE SERVICES IN MULTIPLE FREQUENCY HYPERBANDS

(57) Abstract

A system and method of providing seamless interoperability for a mobile station roaming between cellular telecommunication systems (31) operating in multiple hyperbands such as the 1900-MHz PCS hyperband and the 800-MHz cellular telephone hyperband, utilizing United States cellular standards. An enhanced inter-exchange communications protocol based on IS-41 is utilized to communicate information required for seamless interoperability between mobile switching centers (MSCs) (MSC1 and MSC2). The enhanced inter-exchange communications protocol comprises a plurality of signaling messages (41 and 51) and a plurality of modified message parameters (42 and 52) within the signaling messages. The modified message parameters are modified to include information elements (43 and 53) required for seamless interoperability between the multi-hyperband capable exchanges and are added as optional (overriding) parameters to the signaling messages.



# INTERNATIONAL SEARCH REPORT

Interna I Application No
PCT/SE 97/01296

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/22 H04Q7/30 H04Q7/38

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ' | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No |
|---|---|---|
| A | ISAKSSON M ET AL: "D-AMPS 1900 - THE DUAL-BAND PERSONAL COMMUNICATIONS SYSTEM" ERICSSON REVIEW, vol. 72, no. 2, 1995, STOCKHOLM, SE. pages 73-79, XP000513128 see page 75, right-hand column, line 13 - page 77, middle column, line 21 --- | 1-3, 15-17 |
| A | DUPLESSIS P ET AL: "TOWARDS A COMBINED GSM 900 DCS 1800 SYSTEM" PROCEEDINGS OF THE 5TH NORDIC SEMINAR ON DIGITAL MOBILE RADIO COMMUNICATIONS, DMR V, 1-3 DEC 1992, HELSINKI, FI, pages 89-92, XP000457840 --- | |
| X,P | WO 97 14263 A (TELEFONAKTIEBOLAGET LM ERICSSON) 17 April 1997 see the whole document ----- | 1-21 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex

' Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 28 January 1998 | 04/02/1998 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Behringer, L.V. |

Form PCT/ISA/210 (second sheet) (July 1992)